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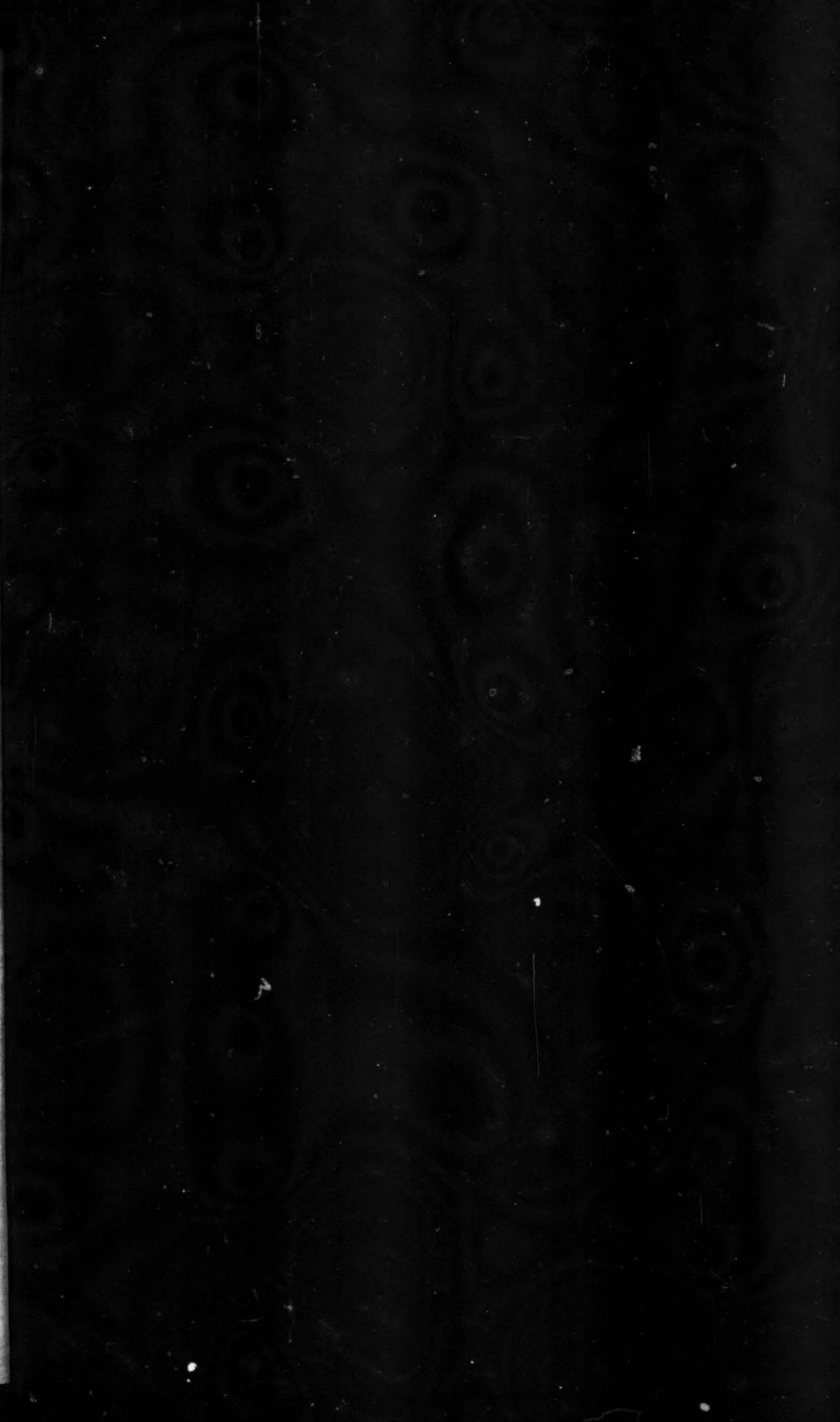
OBSERVATIONS ON THE BEHAVIOR OF ANIMALS
DURING THE TOTAL SOLAR ECLIPSE OF
AUGUST 31, 1932.

BY WILLIAM MORTON WHEELER, CLINTON V. MACCOY,
LUDLOW GRISCOM, GLOVER M. ALLEN, AND
HAROLD J. COOLIDGE, JR.

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2. WHEELER, WILLIAM MORTON, MACCOY, CLINTON V., GRISCOM, LUDLOW, ALLEN, GLOVER M., AND COOLIDGE, HAROLD J., JR.—Observations on the Behavior of Animals During the Total Solar Eclipse of August 31, 1932. pp. 33-70. March, 1935. \$0.75.

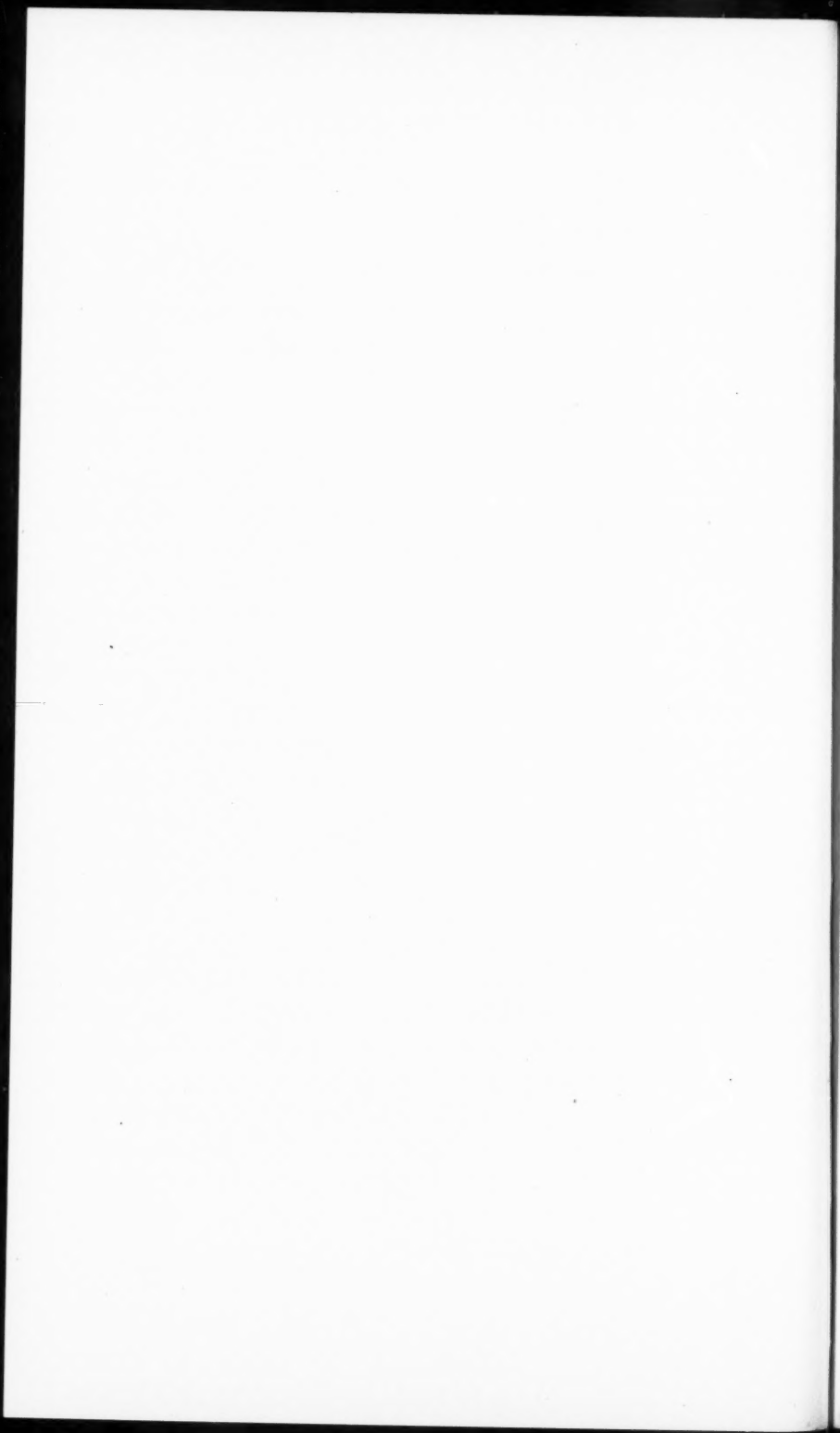


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INTRODUCTION.

By HAROLD J. COOLIDGE, JR.

A SEARCH of astronomical records of total eclipses of the sun has revealed occasional references to unusual behavior of bird and animal life that has been attributed to the effect on them of the total eclipse. The earliest record that the Committee has come across is that of the total eclipse in 1544 when a note was added mentioning the fact that "birds ceased singing," and again in 1560 there is a statement that "birds fell to the ground."

The historical study of this question produced scattered observations on the behavior of birds, mammals, some insects, and plants. In most cases these observations were made by astronomers who were primarily occupied with observing the eclipse, and only in the case of cloudiness was there much time to note the behavior of animals, and then only when they had the good fortune to be in a situation where any animals were close by.

The occurrence of the eclipse of August 31, 1932, at three-thirty (standard time) in the afternoon with a zone of totality extending through a considerable farming district of Maine, New Hampshire, and northeastern Massachusetts gave a splendid opportunity for a study of the effect of a total eclipse on the behavior of wild and domestic animals. The curiosity of the public, as well as of scientists, had been aroused on this subject by the scattered reports from previous eclipses and it was with the purpose of making a more careful and comprehensive study that the eclipse behavior committee of the Boston Society of Natural History was organized. This committee included ten members, as follows: Glover M. Allen, Thomas Barbour, Harold J. Coolidge, Jr., Ludlow Griscom, F. H. Kennard, Clinton V. MacCoy, George H. Parker, Charles H. Taylor, William M. Wheeler, and Edward Wigglesworth. In the following account

Professor Wheeler has dealt with the behavior of insects, Dr. MacCoy that of cold-blooded vertebrates, Mr. Griscom that of birds, Professor Allen and Mr. Coolidge that of mammals.

The problem of obtaining a large number of observations from varied localities was possible only through the active help and coöperation of many newspapers, particularly those enjoying a wide distribution in New England. The Committee planned to make a study of observations procured in three ways.

First: by the general public, including anyone who was sufficiently interested to send in a record of what he or she saw.

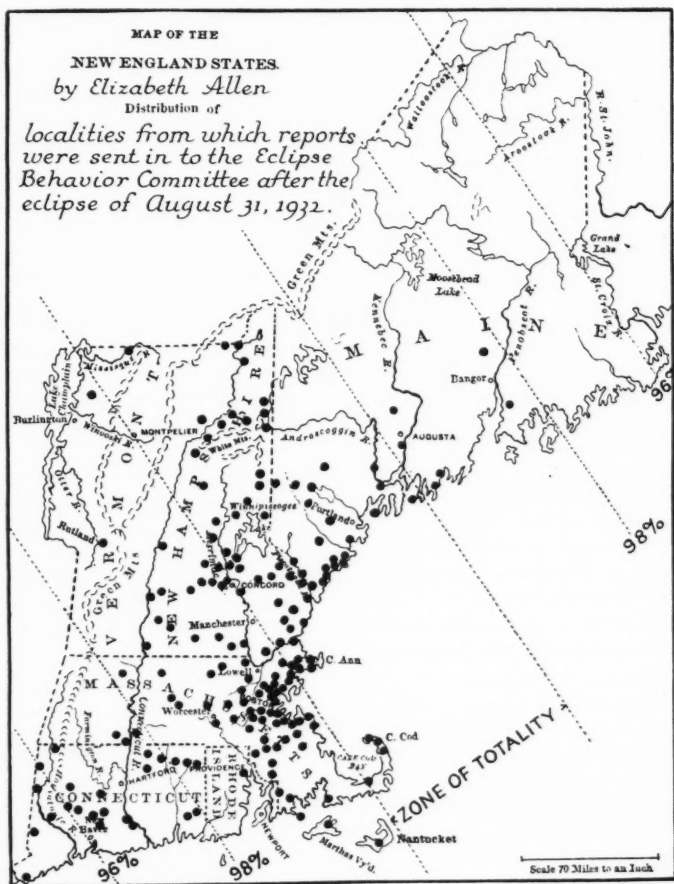
Second: an official report by the game wardens of various states.

Third: by reports submitted by naturalists who occupied definite places in the zone of totality, especially adapted for the observation of some group of animal or insect life in which they were particularly interested.

The returns from these different methods of observation were very gratifying, and only a small number had to be discarded for one reason or another. These observations were divided into six groups, namely, birds, mammals, insects, fishes, reptiles, and flowers. The observations under each group were entered on a separate card with the notation of the observer, time, place, and behavior. Also a map was prepared of each group of observations, showing the exact localities where the records had been made. This material was then assigned to different scientists who had been particularly chosen to make a study of it, using in each case a unified system of handling the material. Acknowledgements were also sent out to the people who so kindly wrote in their observations.

Inevitably the editing and study of these records and the preparation of final reports by the men working on each group have taken a considerable time. Most of the important findings are recorded in the following paragraphs.

The Eclipse Behavior Committee takes this occasion again to thank those people of New England who took the trouble to make observations and send reports of them to the Secretary. Its thanks are due also to the following newspapers: The Boston Globe, The Boston Herald and Traveler, The Boston Transcript, The Boston Post, The Boston American, and the Christian Science Monitor, all of which, by the wide publicity they gave this committee, with important space often on the front page and mention in the radio broadcasts, greatly helped to spread the news of the survey. The



committee also wishes to thank the fish and game commissioners of New England for their coöperation in obtaining reports of observations from their fish and game wardens.¹

The accompanying map shows the approximate distribution of points from which observations were received in New England. Often several observations were sent in from the same general locality. The western limit was Troy, Ohio, and the eastern limit Bradford, Maine. The northern limit was Canaan, New Hampshire, and the southern limit Greenwich, Connecticut.

About 44% of the localities reporting were within the zone of complete totality, about 44% within the zone from the edge of totality to the line where it was 98% total, and about 12% in the adjoining zone where the eclipse was less than 98% total.

The total number of recorded observations used by the Committee in this survey was 498. Of these, 222 or 44.5% were observations of wild and domestic birds, 170 or 34.5% were observations of wild and domestic mammals, 65 or 11% were insect observations, 36 or 9% were reptile or fish observations, and 5 or 1% were plant observations.

The report which follows does not give us sufficient information in the case of many species of birds, mammals, and insects that were observed during the eclipse, to justify the drawing of definite conclusions about their behavior. We believe, however, that this is the first comprehensive and scientifically conducted study of the behavior of animal life during a total eclipse and that it answers many questions of general as well as of scientific interest which are not explained in the published records of previous eclipses.

INSECTS.

By WILLIAM MORTON WHEELER.

During the total solar eclipses of the past, most observations on animal behavior have naturally been confined to birds and mammals. We have found, however, a few records of modifications in insect behavior. During the eclipse of July 28, 1851, Arajo, at Lille Edet, Sweden, noticed that "a swarm of ants, which were busily carrying their burdens, stopped and remained motionless till the light reappeared," and Svangren, in the same locality, noticed that a "bee

¹ We are grateful to the Bond Astronomical Club for their contribution towards the publication of this report.

seemed to hasten home." During the eclipse of May 1900, Rev. A. Morford, at Ovar, Portugal, found that "ants returned from their journeys and collected around their holes, but did not enter," and Sharp, at Santa Barbara made the following note: "Bees stopped humming during totality. Hard at work immediately after, but butterflies (clouded yellows, swallowtails, etc.) did not recover equanimity for some time." Absolute stillness was noticed in crickets and ants.

Many more observations were made during the total eclipse of August 31, 1932 in New England and Ontario. They relate to a number of common insects, which in most cases cannot be specifically identified, since the observations were not made by professional entomologists. The following reports are therefore grouped under family and generic heads in taxonomic order.

COCKROACHES (*Blattidæ*).—W. J. Bielvich, Lawrence, Mass. reports that he was "informed by a lady that shortly after the total eclipse her pantry was greatly infested by cockroaches." (Probably *Ectobia germanica*).

CRICKETS (*Gryllus* sp.).—"Black crickets. With increasing darkness these were obviously more noticeable for their chirping than before the eclipse in the place where we were sitting" (Prof. Glover M. Allen, Brunswick, Me.)—"At 3.15 crickets chirped" (M. E. Almy, New Bedford, Mass.)—"Crickets became very noisy during the darker period" (E. W. Backus, Ayer, Mass.)—"During the time of totality not a sound was heard except the chirping of numerous crickets" (Vernon Bailey, Squam Lake, N. H.)—"Noted incessant chirping of crickets" (F. L. Baker, Annisquam, Mass.)—"Could only hear the noise of crickets" (H. Bowley, Dedham, Charles R., Mass.)—"Crickets began to chirp before totality, when sun was two-thirds hidden. Cricket music was evidently on for the evening as it continued" (H. B. Boyce, S. E. of Conway, N. H.)—"In the stillness of totality crickets began to chirp and they seemed to make much louder chirps than usual" (E. G. Callahan, New Braintree, Mass.)—"Heard crickets chirping throughout the eclipse" (A. A. Carter, Fryeburg, Me.)—"We could hear crickets very plainly although it may have been that we were looking for the unusual" (W. E. Chase and Mrs. H. S. Durkee)—"Crickets were singing in the yard and nearby places while it was dark" (Chas. A. Clark, E. Lynn, Mass.)—"Crickets were unusually noisy" (J. A. Cole, Epping, N. H.)—"Crickets were chirping" (K. F. Coney, Limington, Me.)—"Crickets

chirped" (H. V. Dawson, Bradeford, Me.)—"We also noticed that the crickets chirped" (Mary F. Dunn, Dorchester, Mass.)—"I noticed near totality that the crickets began chirping as if night were coming on" (G. A. England, Laconia, N. H.)—"At 3.30 the chirping of crickets became so loud as to command attention (time noted when turkeys entered barn); it had not been noticed previously to this time, and it was observed that the chirping gradually diminished shortly after totality" (E. B. Hald, Denmark, Me.)—"I noticed that the crickets started singing around two o'clock and continued since that time, with the exception of extreme totality, when the air was still" (Alice E. Hall, Lancaster, N. H.)—"The crickets set up a lively chirping just as they do at nightfall" (H. C. Harrington, E. Kingston, N. H.)—"Crickets were chirping all the time" (B. N. Hodgson, Bean Hill, Belmont, N. H.)—"During the darkening process of the eclipse, I noticed how lustily the crickets sang; when the sun was bright they were still" (Mrs. M. L. Kingman, S. Hampton, N. H.)—"At about one quarter eclipse the crickets started chirping and soon there was a continual chorus lasting through the entire eclipse and some time after" (S. J. Lowe, E. branch of Westport R., Westport, Mass.)—"At 4.15 crickets began to chirp and continued for one hour" (Mr. and Mrs. F. L. Oaks, Framingham, Mass.)—"At the time of totality there was a strange hush over everything—all the insects stopped their "fiddling," resuming it as soon as the light returned" (E. D. Oliver, Wellfleet, Cape Cod, Mass.)—"The crickets chirped as loud as on any summer's night" (Mrs. W. J. Plummer, West Lebanon, N. H.)—"What I noticed especially during the eclipse was the chirping of crickets as darkness came on" (Chas. W. Remick, Conway, N. H.)—"Crickets singing" (Mrs. A. Raitt, Elliot, Me.)—"Crickets started their night song" (Mrs. L. Rogers, Westwood, Mass.)—"Crickets chirped" (A. A. Shurrocks, Nantucket, Mass.)—"Crickets increased their chirping" (J. A. Stenart, Somerworth, N. H.)—"Crickets were singing" (L. L. Strickland, Wells, Me.)—"Crickets began to sing" (A. H. Teague, S. Peabody, Mass.)—"The crickets began to chirp their even-song by four and apparently acted as they usually do in early evening" (G. L. Thompson, Dighton, Mass.)—"About 4 P.M. crickets began to chirp as they do at sunset" (R. E. Trask, Beverley, Mass.)—"Noticed that crickets started their chatter and later, as light appeared, they stopped" (Chas. E. Tribon, Sewer Beds, Brockton, Mass.)—"At about 4.30 the crickets began to chirp and have kept it up since"

(H. T. Wheeler, Lexington, Mass.)—"The fall crickets chirped a full chorus" (Anonymous, Warner Village, N. H.)—"At Old Orchard Beach, with the totality phase of the eclipse, myriad crickets set up their shrill calls, continuing until the sun came forth again, when they became silent" (Anonymous, newspaper clipping, Old Orchard, Me.)

KATYDIDS (*Locustidae*). There are only three observations on these insects and only the first refers without doubt to a true Locustid. "At the darkest period of totality a small Locustid of some kind started singing near us with a thin, high-pitched "zee-ing," not very loud but more or less continuous, such as I usually have heard only in evenings. It stopped after the sun came out again." (Prof. Glover M. Allen, Brunswick, Me.)—"During the darker period the katydids remained silent" (E. W. Backus, Ayer, Mass.)—"The katydids set up their chanting which was kept up a few minutes and then turned out weakly as though they had been led into an error of which they were ashamed" (W. E. Chase and Mrs. H. S. Durkee).

GRASSHOPPERS (*Acrididae*).—"Two grasshoppers climbed to the top of a sunflower and clung half way motionless. They made no move till after eclipse" (J. A. Stenart, Someworth, N. H.)

DRAGON-FLIES (*Odonata*).—I. R. Marshall, Reading, Mass., and G. McFarland, Atlanta, Ontario both mention dragon-flies as acting "very peculiarly" or "confused" during the eclipse, but the behavior is not more clearly described.

CICADAS (*Cicadidae*).—"The shrilling of the locust, very noticeable before the eclipse began, ceased altogether" (B. N. Hodgson, Bean Hill, Belmont, N. H.)

BUTTERFLIES (*Diurnal Lepidoptera*).—"The butterflies were not seen" (Mrs. W. J. Plummer, West Lebanon, N. H.)—"The butterflies were slower in leaving but began to disappear and by 4.20 none was in sight" (G. L. Thompson, Dighton, Mass.)—"Butterflies disappeared but reappeared about three quarters of an hour after the eclipse" (A. A. Shurrocks, Nantucket, Mass.)

MOTHS (*Nocturnal Lepidoptera*).—"Night millers were thick" (C. M. Davis, Long Island, Casco Bay, Me.)—"I did see one moth" (W. P. Smith, Wells River, Vt.)—"Many night-flying moths appeared and flew about ten minutes" (H. T. Wheeler, Lexington, Mass.)—"Numerous moths flew about during the latter part of the eclipse" (W. M. Wheeler and T. Barbour, Beverly Farms, Mass.)

MOSQUITOS (*Culicidae*).—"For the half hour previous to the eclipse, mosquitos were noticeably absent while we sat waiting in the

warm sun, on the ledge. Towards the end of totality with the drop in temperature and the feeling of increased dampness, dozens of them came from their hiding places in the surrounding grass and started to bite. They were still about, a few minutes after the eclipse was practically over. This was the most definite reaction to light and coolness that we saw" (Prof. Glover M. Allen)—"A mosquito bit me at 3 P.M. during the semidarkness" (Vernon Bailey, Squam Lake, N. H.)—"A great many mosquitos at 4.15 P.M." (H. Bowley, Dedham, Charles R., Mass.)—"Mosquitos were noticed after the eclipse and more had been noted previously" (A. A. Carter, Fryeburg, Me.)—"The mosquitos were thick" (C. M. Davis, Casco Bay, L. I.)—"A swarm of large mosquitos appeared and pestered us terribly during the last three or four minutes before the corona appeared. They acted wildly and our stockings attested to the bites, for they drew blood and never let up" (M. E. Hartman, Newburyport, Mass.)—"Mosquitos in some places took the eclipse darkness as an excuse for coming abroad early. Mrs. George L. Moore of Wellesley reports that swarms of them appeared at her home shortly before the time of greatest darkness and disappeared again when the light returned" (newspaper clipping)—"Mosquitos began coming down from trees and out of grass and were very vicious, especially between 4.15 and 4.45 P.M." (Mr. and Mrs. F. L. Oaks, Framingham, Mass.)—"There were some mosquitos at 4.30, more and very hungry at 4.45, not so thick at 5.00 and gone at 5.30" (P. F. Quinn, Stony Brook, Conn.)—"Only time I was molested by mosquitos was two minutes during total eclipse" (S. Stockman, Salisbury, Mass.)—"At 4.15 mosquitos began to appear in considerable numbers and at 4.25 were as troublesome as at night" (G. L. Thompson, Dighton, Mass.)—"Mosquitos came out and I was bitten" (W. C. Weller, Gloucester, Mass.)—"Mosquitos flew about" (H. T. Wheeler, Lexington, Mass.)—"Mosquitos emerged from the grass and were annoying during the darker portion of the eclipse" (W. M. Wheeler and T. Barbour, Beverley Farms, Mass.).

GNATS (*Chironomidae*).—"Gnats were in milling swarms as at twilight" (E. D. F. Jeffers, Richford, Vt.)

HOUSEFLIES (*Musca domestica*).—"The reports on the behavior of houseflies during the eclipse are very meager. (F. D. Hazzard, W. Acton, Mass.) "noticed great swarms of houseflies clinging to the screen door" and (G. L. Thompson, Dighton, Mass.) noticed that "the houseflies seemed to be but little affected."

HONEY-BEES (*Apis mellifica*).—The observations on honey bees during the eclipse are of considerable value because several of them were made by apiarists, who are well-acquainted with the normal, every-day behavior of these insects. Mr. D. T. Troyers, Jr., N. Weymouth, Mass., noticed that a swarm of perhaps two hundred bees that had been visiting a flowering bush for two days, showed signs of "apprehensiveness" about two minutes before eclipse totality, when it grew darker "they ceased their labors on the bush and flew round about. By the time the greatest degree of darkness had arrived there was not a bee to be seen. After a lapse of twenty-two minutes they again appeared." Mr. E. Kellstrand, Rockland, Mass., reports as follows: "I have fifteen colonies of bees which I watched closely. The field bees had been working heavily on goldenrod all day and everything was normal till darkness began to come on, when they came home in unusually large numbers. When it was darkest they had not all reached the entrances of their respective hives and it was then too dark for them to see their way, so they kept flying about in the air or landed in the grass, till it lighted up again. Then they found their way home and became very quiet. Some stragglers still came in from a distance. Later, after the eclipse was nearly over, they ventured out again very slowly." The following reports are similar: "I have four hives of bees. The day was a good one for them to be out gathering honey and therefore when the eclipse began bees were going out and returning at a lively rate. With the first perceptible dimming of the light there was no change in the bees' activity, but as darkness increased the outgoing bees diminished in numbers and the return battalions grew larger. When the light was almost at the dimmest point no bees were leaving the hives, but the returning individuals were pouring in by the thousands. The space above the hives was like a funnel into which bees were literally pouring from every direction. When the light began to increase there was not a bee to be seen in the air. For them evidently it was the sudden advent of night. I watched to see whether with the return of light they would go out again. Normally they go out till dusk, but in spite of the bright sunshine following the eclipse only an occasional bee ventured forth" (T. Clinton Brockway, Hingham, Mass.).—"From my point of observation it was interesting to see the honeybees stop working and the night insects start singing, all in less than twenty minutes" (T. M. Spalding, Bradford, N. H.).—"I also observed several hives of honeybees and noticed that they

all hurried back to their hives" (H. F. Joray, Sharon, Conn.)—"Mrs. B. C. Green of Keene, N. H. reported that she noticed a number of bees that went away when it was darkest but came back again when it was over"—Bees working on a plant "flew around and around and finally flew away" (H. F. Chamberlain, S. Hanson, Mass.)—"The bees observed seem to have been more affected than other insects. At 3.45 they apparently were nervous and began to seek shelter. At four practically all bees had disappeared from flowers in my garden and at 4.30 none could be found on examining a large number of flowers" (G. L. Thompson, Dighton, Mass.).

The two following accounts by H. T. Wheeler, Lexington, Mass. and Joseph R. Burgess, Nantucket, Mass. give many additional details: The former writes: "During the period of the eclipse today I closely watched the behavior of eleven strong colonies of bees. They have been particularly busy on the big late honey flow from yellow goldenrod and buckwheat, and were very active at the beginning of the eclipse at about 3.30 o'clock. The temperature was 85° F. and the sky partly overcast, with the sun shining through now and then. Here at Lincoln, where these observations were made, the clouds thickened and only a short sight of the sun at 4.30, just at the height of the eclipse, was obtained. There was no direct sunlight afterward. At 4 P.M. not much change in temperature or in the activity of the bees could be noted. At 4.10 P.M. many more were coming in than were going out. At 4.20 P.M. the air was full of returning bees. Those leaving the hives flew about on erratic courses and came back. They also became excited and cross and it became dangerous to stay within forty feet of the hives. I beat off two attacks and returned to a safe distance. At 4.30, the period of greatest darkness, the fronts of the hives were covered with bees all trying to get in at once. At 4.40 a few stragglers came in—those caught in the dark a long way from home. At 4.45 there was not a bee in sight, not a sound in the apiary except the hum in the hives that is usually heard at night when the ear is held close to the hive. There was no outside activity, all having apparently arrived home. At 4.55 a few scouts came out and flew around, but as the clouds had become quite dense and the temperature had dropped to 74°—only 6 degrees above the supposed minimum at which bees work (I have, however, seen those which are hybrids, working at 55° F.)—the whole 2,750,000 of them, more or less, decided to call it a day and do house work. Probably the bees would have worked till nearly seven

had the day been clear, as they usually work for sometime after sunset."

Mr. Burgess's observations on five hives were published in the *Nantucket Inquirer and Mirror*, September 10, 1932 and are here reproduced:—

"Nothing unusual was noted at first. The flight to and from the fields seemed normal. As it darkened the flight quickened and at the time of the greatest totality, the air was full of bees—a great roar of wings ensued and the entrances to the hives were blocked with bees trying to get in. Hive No. 3 appeared to have the least number. The great rush of bees was over at 4.32 in all hives except in No. 3. The others apparently had settled for the night. Guards walked back and forth at the entrances and there was no flight in the fields and little from the fields. Ordinarily the flight tapers off as sunset and night approaches. Hive No. 1, which is composed of some black bees, started to drive the drones from the hive. Bees do this only after the nectar flow falls, especially in the Fall.

Hive No. 3, not in the shade, showed a steady flow of bees for five minutes after the others.

As the minutes passed and the sun grew larger, the bees appeared disturbed. Now and then one would look out, fly out a few feet and then return to the hive. A few ventured forth.

At 4.50 everything was normal again. Just the sort of flight that occurs early in the morning. Flight getting stronger continually."

Mr. Burgess offers the following as his explanation of the behavior of the bees:

"Hive No. 1 consists of hybrid bees. The queen was bought for a pure Italian, but apparently she isn't. Black bees are more nervous than the Italians and this particular hive has given me trouble by robbing the others when the clover flow stopped in July. Either the bees were upset and this started them driving out the drones or, by some sense we know nothing about, they decided that the short Fall days were coming and it was time to get rid of the drones. The latter is open to serious argument, of course.

"As to Hive No. 3. The hive itself received more light at the time of the eclipse; the light conditions in the fields where the bees were working were, as far as I know, the same. Why should the bees continue to pile in this hive five minutes or more after the flight of the others had practically stopped? Possibly the bees in that hive had been working at a greater distance, and the fact that these particular bees were in a light hive was a coincidence, I don't know."

Only two of the observers failed to notice anything peculiar in the behavior of the honeybees during the eclipse. J. A. Stenart (Somerset, N. H.), reports that "the bees on the bamboo bush, when darkness obscured the sun, evidently did not mind, but kept on gathering honey," and S. J. Lowe (Westport, Mass.) found that "the bees continued to work all the time as though nothing out of the ordinary was going on." These observations cannot be given much weight, however.

BUMBLEBEES (*Bombus* sp.)—A single observation on a bumblebee is reported by Margaret Harwood, N. Truro, Cape Cod, Mass.: "A bumblebee flew onto the coatsleeve of one of the men who were sitting on Mr. Aldrich's veranda to observe the eclipse. The bee became lifeless during totality. Several of the men blew smoke on to it but it did not move until the sky was decidedly lighter after totality was over." The reaction to darkness and lowered temperature might be expected since bumblebees not infrequently pass the night in flowers in a quiescent condition.

WASPS (*Vespa* sp.)—Mrs. L. Rogers, Westwood, Mass. noticed that "wasps went into their nest" during the eclipse.

ANTS (*Formicidae*).—The behavior of ants during a total eclipse might be expected to resemble that of honeybees and wasps, but the observations reported are too few to admit of a conclusion. According to G. McFarland (Atlanta, Ontario), "A number of ants of the species *Monomorium pharaonis* and *Camponotus pennsylvanicus* continued to hurry about apparently unmoved," and A. A. Carter (Fryeburg, Me.) noticed that "a rock upon which people had been seated for an hour during the early part of the eclipse was a mass of very active ants about five minutes after totality." Of course, the ants mentioned in the latter observation may have congregated on the rock because their nests had been disturbed by the movements of the spectators. F. D. Hazard, W. Acton, Mass., noticed "flying ants coming out of their homes in the soil." This was evidently the beginning of a nuptial flight, the stimulus to which was probably the fall in temperature during the eclipse, since it is well known that these flights are initiated by temperature and not by photic stimuli.

REMARKS.

So much of the behavior of insects is of the tropistic or reflex type that we should expect these organisms to respond readily to such stimuli as the rather rapid diminution of light, fall of temperature,

and increase of humidity observed during a total eclipse of the sun. Nocturnal insects, like the cockroaches, crickets, moths, mosquitos, and some katydids, should exhibit their typical activities, and diurnal forms, such as the grasshoppers, meadow locustids, dragonflies, cicadas, butterflies, some gnats, houseflies, honeybees, bumblebees, wasps, and ants should suspend their activities during the period of darkness and resume them as soon as normal conditions supervene. The observations cited above fulfil these expectations.

Field observation on insect behavior is, of course, difficult during a total eclipse, because the observer is apt to be very desirous of witnessing at the same time a wonderful astronomical event, which he may never again be able to contemplate. Moreover, notes on the activities of single insects are apt to be indecisive under the most favorable conditions, and the time for repeated observation during an eclipse is quite insufficient. On the other hand, observations on insect aggregations and societies are much more satisfactory since they have at least a rudimentary statistical value. For this reason the numerous observations reported in the preceding paragraphs on the crickets, mosquitos, and honeybees are the most instructive. Nearly all the observers call attention to the chirping of crickets during the darker period of the eclipse and several mention an intensification of this activity. Perhaps, however, this is due to concentration of attention or expectation and therefore to be attributed to the unusual state of the observer. In observations undertaken during future eclipses both this and other dubious details suggested by the reports, will no doubt receive attention. Enough has been learned to show the interest of the subject and to suggest further problems and methods of greater precision in observation. Even the astronomers had to learn what to expect during a total eclipse before they could make elaborate preparations beforehand for securing accurate quantitative data. The biologist may be expected to adopt a similar course.

COLD-BLOODED VERTEBRATES.

By CLINTON V. MACCOY.

A total of thirty nine observations on cold-blooded vertebrates was reported to the Boston Society of Natural History. Of these thirty six were used in making this report.

In preparing this report on behavior of these vertebrates during abnormal photoperiodic conditions it is interesting and deplorable

to note how little is known of the normal actions of these animals and their ordinary behavior and response to the usual daily and seasonal photoperiodic fluctuations. Movements of fishes may be attributable to varying intensity and duration of light, food, temperature, currents, chemical or physical constitution of the water, or to breeding stimulus which may be a corollary of duration of light.

FISHES.

Fifteen observations were made on fishes by fourteen observers. Of the fifteen observations made, only seven contain the correct names of the fishes or give sufficient data to enable positive identification. This leaves eight observations made on "fish," "small fish," "small fish like minnows," "trout," and the like which are not referable to any species.

BROOK TROUT. (*Salvelinus fontinalis* (Mitchill))—It is probably generally agreed that the brook trout is sensitive to meteorological changes, but as to just how these changes affect this species has not been satisfactorily explained.

Mr. G. R. Bowman, who is probably referring to this form, reports that at Lost River, Beaver Pond, N. H., "I rose trout very early in the morning and at sunset but as the sun became obscured and dusk began to shadow the waters at the moment of eclipse I rose and hooked two trout, landing them both, one $14\frac{1}{2}$ inches and one 11 inches, then the sun came out again and not another rise till dusk again."

Another report, presumably relating to this trout, telling the opposite story, is from Mr. A. J. Stobie, who reports from the path of totality in Maine:

"We had several men at the different hatcheries in this locality watching the fish and some of them were being fed at the time, just before the eclipse occurred. The fish were feeding good, but as soon as it grew dark they immediately stopped feeding and went to the bottom."

While this is the antithesis of Mr. Bowman's report, it must be realized that under hatchery conditions and with apparently regular feeding times, the fish may have developed a diurnal rhythm different from that of the normal fish in natural habitat.

GOLDFISH. (*Carrassius auratus* (Linné))—Mr. Gregg reports that at the Middlesex Fells Zoo, in Stoneham, Mass., during the eclipse, which was partial at this point, "The golden carp left the depth of

the pool and started surface feeding as they do every evening." I have assumed that these "golden carp" belong to the species under which this account is given.

Meek in *The Migrations of Fish* (1916, p. 177) writes that, "the members of the carp family, as a whole, exhibit usually an alternation between relative passivity during the day and activity at night."

Mrs. J. J. Conners of Somerville, Mass., reports that the goldfish remained absolutely still.

One observation, from Mr. G. H. Fuller, of Allston, Mass., tells of two goldfish, one of the fancy, long-tailed variety, the other of ordinary form, which had lived together for many months. During the eclipse the ordinary goldfish ate off the tail of its companion and killed it. While this action may not be directly attributable to the eclipse of the sun, it is thought advisable to include it for sake of completing the records of observation on this species.

COMMON PICKEREL. (*Esox niger* Le Sueur)—From Charles River, Dedham, Mass., Mr. H. Bowley writes that, "pickerel that always jump out of water in this part of the river at dark, began jumping out during the darkness of the eclipse."

Mr. James A. Peck reports from Fitchburg, Mass., that a "half hour before eclipse the fish jumped continually . . . , and I never saw fish so ferocious, especially the pickerel."

SMALL-MOUTHED BLACK BASS. (*Micropterus dolomieu* Lacépède)—Mr. Harry M. Farr writes that, he began fishing for black bass in Littleton, N. H., just as the eclipse commenced and that the fish bit so well that he caught twelve previous to totality. They stopped biting, however, one minute before totality, and just after totality two were caught. The observer says he stopped fishing when the sun was about half clear.

From near the Winnepesaukee Post Office, Lake Winnepesaukee, N. H., where the view of the phenomenon was perfect during the entire period of totality, Mr. E. K. Robinson writes that he passed a man and his wife who had been fishing for bass from a bridge for several hours. They said that there had been no difference in the way the fish bit during the total eclipse, for they had not bitten during the entire day.

This same gentleman said he observed a most unusual spectacle while the sun was under eclipse. The visibility in the lake, which was especially calm, became unusual while the sun was under the shadow of the moon, and it was possible for him to see to the bottom

of the lake for a great distance from the bridge. He said that hundreds of fishes became visible, mostly small ones like minnows, but numerous larger fish which were presumably bass. While the sun was obscured all the fishes which he observed came up very near the surface of the water. They did not, however, indicate any greater interest in the bait on the observer's hook than they had before the eclipse began. The astonishing increase in the visibility through the water and the tendency of the fishes to rise to the surface during the eclipse were two unusual features which this observer especially noted.

WHITE PERCH. (*Morone americana* (Gmelin))—Mr. Norman S. Easton reports that during the afternoon of the eclipse he was fishing for white perch on South Watuppa Lake, near Fall River, Mass. At first his luck was poor, but as the sky became darker, the perch bit more vigorously. When the shadow had passed and the sky again became clear, the fish ceased to bite, but again resumed their activity when the real evening twilight descended.

Observing at Great Lake, Belgrade Lakes, Me., Sarah S. Drake writes that as she waded through the lake two white perch came within three feet of her and swam alongside. Soon two more did the same, and then from the deeper water appeared a large one and a small one which joined the others, and when she reached the landing, the fish swam under it.

AMPHIBIANS.

Nineteen persons made as many observations on the behavior of amphibians. Five of these observations are referable to a definite species. The others can be given no more than a generic name. These reports deal only with frogs and toads, no observations on salamanders having been reported.

AMERICAN TOAD or FOWLER'S TOAD. (*Bufo americanus* Holbrook or *B. fowleri* Garman)—Three reports refer definitely to toads but it is impossible to tell whether *B. americanus* or *B. fowleri* is meant.

Of photoperiodism in *B. americanus*, Dickerson (1906, p. 80) writes: "The toad remains quietly sleeping throughout the greater part of the day, thereby keeping himself from being a nuisance and also saving himself from the danger of being stepped upon. But at sunset, or often earlier than that, he comes out from his bed under porch or shrubbery and starts on his regular tour over lawns and through gardens."

Their appearance at sunset or earlier may possibly have been made

in advance of the regular hour, but with only three observations, coupled with the fact that toads are often found abroad in daytime, it is unsafe to draw conclusions regarding any abnormal behavior. However, for sake of completeness the observations may be listed.

Jeanette Norcross reports that at Brockton, Mass., throughout the eclipse several toads were busy catching insects which she describes as winged ants.

Mr. V. C. Colton writes that at North Rochester, N. H., a toad appeared close to his feet and remained there until after the eclipse was over, when it hopped away out of sight. This report probably deals with *B. americanus* as it appears to be in a region somewhat north of the usual range of *B. fowleri*.

A newspaper article apparently referring to Dover, Mass., and to which the initials 'N. H. S.' are attached says:

"When darkness shut down as the period of totality approached a large flock of toads in a home garden sprang suddenly into action, and, large and small, began hopping about in frantic search for insects and worms. This extraordinary activity attracted the eclipse observers' attention. It continued until the sun again appeared, when the toads resumed their ordinary day-time quiet."

SPRING PEEPER. (*Hyla crucifer* Wied.)—Dickerson (1906, p. 143) writes that this form calls during the daytime usually from the corner of moss or leaves. She seems to infer (1906, p. 147) that from late July even into November they may be heard calling. This form is generally known to give occasional, intermittent calls throughout the day, but becomes more vociferous as dusk approaches.

Mr. Wendell P. Smith, of Wells River, Vt., reports that "a *Hyla crucifer* called for several times during the gathering gloom, but as that is frequently done at different times of day and for no apparent reason, it seems hardly chargeable to the eclipse."

From Hingham, Mass., Claire H. Cowell writes: "The 'peepers' as we call them started and did not stop until quite a bit after the sun started out again."

Sarah S. Drake, observing at Great Lake, Belgrade Lakes, Me., says that "when the sun was a small slice the frogs were peeping in the swamp as if it were night."

TREE TOAD. (*Hyla versicolor versicolor* (Le Conte))—Dickerson (1906, p. 119) mentions that this species sings at dusk, on rainy days, or during damp weather.

From Hardwick, Mass., where the sun was at no time visible, due

to heavy clouds which increased the darkness, Dorothy A. Baldwin writes that "tree toads 'purred' for fifteen minutes or so at the height of the eclipse."

An observer whose identity has been lost writes that "near totality . . . a tree toad started in to give us his nightly concert but stopped as soon as the light began to appear."

Mr. S. J. Lowe made observations at the East Branch of the Westport River, at Westport, Mass., and states: "I also noted that several tree toads started peeping just previous to the start of the eclipse, this continuing during the whole eclipse."

It is doubtful whether the last two observations refer to *H. v. versicolor* or not. They may just as probably refer to *H. crucifer*, particularly the last, which refers to the "peeping," and peeping is hardly a term to describe correctly the voice of *H. v. versicolor*.

BULLFROG. (*Rana catesbeiana* Shaw.)—Mr. W. J. Bielvich reports that five minutes after totality at Lawrence, Mass., he observed two large frogs, about 6 inches in length, sitting on the bank of the city reservoir. The caretaker, he says, informed him that they are never seen in the daytime, only at night.

VARIOUS FROGS. (*Rana* spp.)—Under this heading are eight reports referring to frogs which obviously belong to this genus, but to what species it is impossible to determine.

Mr. H. Bowley says that, although frogs are plentiful at Charles River, Dedham, Mass., he heard the sound of a frog only once in a while and could not see any at 4.15 P.M.

From Stoney Brook, Conn., Mr. P. F. Quinn states that at 3.45 P.M. frogs began to call; at 4.15 called more frequently; at 4.31 called strongly; at 5.00 decreased the frequency of calling.

At Limington, Me., Mr. K. F. Coney writes that at 2.26 E. S. T. tree frogs were singing and croaking, but absolute silence reigned at totality, crickets being the first to break the silence.

Frogs were reported croaking at Bradford, Me., Annisquam, Mass., and Conway, N. H., and in Franklin, N. H., frogs were croaking as though it were evening.

REPTILES.

Of reptiles, one turtle and two snakes are definitely named, and one observation deals with "pythons."

PYTHONS.—Mr. John T. Benson from the zoo in Nashua, N. H., reports that "45 minutes before eclipse pythons were very lively,

more so than they have been at any time this summer." Pythons are generally nocturnal feeders.

NORTHERN WATER SNAKE. (*Natrix sipedon sipedon* (Linné))—Mr. W. S. Watson, reporting from Lord's Cove, Lyme, Conn., says that, "a half hour before the eclipse a thirty-inch water snake crawled onto the point of rocks, about twenty-five feet from me, and stayed there until I shot it about twenty minutes after the peak."

EASTERN GARTER SNAKE. (*Thamnophis sirtalis sirtalis* (Linné))—At Woodstock, N. H., about 45 minutes after totality the writer found a garter snake which had evidently been feeding actively during the eclipse because the stomach was so full of food as to produce a large lump in the body.

PAINTED TURTLE. (*Chrysemys picta* (Schneider))—Mr. Gregg, of the Middlesex Fells Zoo, Stoneham, Mass., writes that at 4.25 P.M. ninety-five per cent of the painted turtles left their swimming board and hunted the shelter of the pool, as they do when the sun goes down, but at 4.40 P.M. all were "back to normal" as if nothing had happened.

CONCLUSIONS.

Since the reports are few in number it is well not to draw unconditional conclusions regarding them. On the whole they represent only a meagre smattering of what might be desired should one seriously attempt to make any very definite statement concerning the reaction of such vertebrates to these light conditions. However, a good beginning has been made, as may be readily appreciated when one attempts to locate previous literature on the subject.

Had the eclipse occurred in mid-morning or at noon, results might have been more interestingly different. On the whole, observations indicate a behavior in keeping with regular crepuscular or nocturnal activities of these creatures as far as known. It is here that our embarrassment arises. We must learn more about normal reaction to photoperiodic conditions.

BIRDS.

BY LUDLOW GRISCOM.

There is very little on record regarding the behavior of birds in previous eclipses. As a matter of interest a brief historical summary is given below, prepared by Mr. Harold J. Coolidge, Jr.

Total Eclipse of 1851 in Sweden.

A report by Mr. Arajo says: "In several places birds flew against houses."

Mr. L. Svangren reported: "Immediately before totality I heard all the cocks in the neighborhood crow. A canary bird which was singing cheerfully stopped and seated himself on the highest perch in his cage for as long as the eclipse lasted. Hundreds of small birds which I had not previously seen, and which were swallows and a few sparrows, flew about like mad things, seeking trees and bushes as places of concealment as if afraid to remain in the air. A wagtail remained quiet and continued to feed its young."

Total Eclipse of 1898.

A hen was seen to roost during this eclipse in India.

Total Eclipse of May 1900 in Portugal.

W. Tait of Oporto noted: "3.17 all the cocks crew vigorously. Ring doves in a cage were cooing softly. Fowls went to roost." No special effect was noticed on the fowls, turkeys, and ducks by his wife who remained in Oporto.

Dr. Somes at Oporto reported: "Pigeons being fed were much alarmed and disturbed, stretching their necks upward to the sky as if apprehensive of some bird of prey. They recommenced eating when the sun reappeared."

Baron de Soutellino: The effect on birds was less than he expected. Fowls looked uneasy and some went to roost, yet they never became silent. Wood doves cooed all the time and other birds continued singing.

Rev. A. Morford of Portugal at Ovar: "Sparrows were twittering around their roofs just as if the evening had come, and about fifteen minutes before totality swallows were flitting as at twilight. A little later they disappeared and did not reappear until long after. Fowls in the garden kept up a perpetual uneasy crowing and cackling. They roosted near totality. Shortly after the light returned they came back and set up a triumphant crowing."

H. P. Slade, Estarreja: "A nightingale was heard."

Thanks to the trouble taken by numerous (222) correspondents in sending in their observations, there are sufficient data at hand to warrant certain generalizations as to the behavior of birds during the total eclipse of August 31, 1932. Conditions were far more ideal for observations than in the preceding eclipse, when there was some

discussion of this subject in the press. The activity of numerous species of birds on a summer's afternoon yielded very different results from the meager evidence afforded by the previous eclipse, which took place in mid-winter on a bitterly cold morning shortly after sunrise.

Before, however, taking up the detailed analysis of the behavior of the various birds concerned, something should be said about the observers, and the principles governing deductions regarding the behavior of birds, or any other animals for that matter. The view is taken in this summary that definite proof of any particular bird's reaction to a total eclipse and its degree is quite impossible. The most that observation can do is to provide a strong inference that the bird's behavior, if unusual, was due to this remarkable and unusual phenomenon. It will be apparent that even this inference is not justified unless it can be shown that the behavior of the bird was not really normal for an ordinary August afternoon. In other words it must have acted in a way that it would not normally have done.

There is an additional, purely psychological difficulty on the part of the observer. It is quite apparent from the reports before me that some of the observers started with the *a priori* assumption that the birds would be disturbed or frightened by the eclipse, and anything they did was interpreted as evidence to this effect and so reported.

The observers range all the way from experienced ornithologists, students of nature, and scientists, to farmers and tourists to some point of vantage in the country. It is natural that the great majority had little or no knowledge of the birds they happened to notice. It is very creditable that most of them contented themselves with reporting what they saw, leaving deductions to some one else. I here gladly quote some pertinent observations on this phase of the subject by a correspondent.

"I observed one example of how easily a person not familiar with the habits of birds can be deceived as to the significance of their actions. Just as the darkness was most intense, a male crowned crane spread its wings and ran across the cage with head held low and wings flapping. It would be easy to say the bird was frightened or excited by the darkness. The fact is that not an hour goes by without such a demonstration on the part of one of the several cranes in the cage." (D. J. Harkins, Franklin Park Zoo). Whenever possible I quote similar comments or add them myself in the systematic list beyond.

With these preliminary remarks, we may now list the generalizations in the approximate order of their importance.

(1) The evidence is overwhelming that most birds showed some reactions of an unusual nature to totality, exhibiting behavior characteristic of fear, bewilderment, or a belief that night was approaching.

(2) No birds, however, gave any extreme signs of fear or panic. No behavior reported could be regarded as equivalent to the terror evinced by ignorant men and women during the Middle Ages.

(3) There is not a shred of evidence to warrant the belief that birds were able to sense some impending natural phenomenon, as is certainly true of violent storms, and has been claimed for earthquakes.

(4) No distinctions in behavior can be made between wild native species, domestic poultry, or caged birds.

(5) The evidence is absolutely conclusive that birds of all kinds showed practically no unusual or abnormal behavior in regions where totality was 98% or less. This is of interest, as it indicates a possible similarity between avian and human reactions. Millions of people turned out to see a total eclipse and many thousands travelled some distance to observe one, but they most certainly would not have taken this trouble for a partial eclipse.

(6) Turning now to the comparison of one group or species of bird with another, there is little evidence that one kind of bird was more affected by the eclipse than another, with the possible exception of the shore birds. In fact, the amazing contradictions in the testimony of the observers is the outstanding feature of inquiries of this kind and is at first very puzzling.

We should like to think that herring gulls all showed one type of reaction and chickens another. It is not the case. The reactions of birds to the eclipse were on the whole individual rather than specific. Some gulls and chickens thought night was coming, others did not; some showed alarm, others did not; some gulls and chickens paid no attention to the eclipse whatever. While we have no reliable criteria for gauging individual differences in birds, we know perfectly well that there are such differences, and this type of variation within one species is usually greater than the variation between two different species, if we omit from consideration such habits as are compelled by differences in structure and the nature of the food to be found or captured.

That this is reasonable can be seen by analogy again with human beings. It is possible that the people of one nation are braver than those of another nation, but this difference is a slight average, based on observing millions of individuals over centuries of time. This

difference is relatively insignificant compared with the enormous gulf between the bravest and the most cowardly members of either race. With different groups of birds it is infinitely more difficult to suspect average differences of behavior and practically impossible to prove them. Let us beware, then, of rash and positive generalization about the behavior of birds. No type of speculation is more easy and alluring than the explanation or interpretation of the behavior of animals nor more replete with pitfalls for the unwary.

CAPTIVE OR CAGED BIRDS.

There are reports from two zoological gardens (1) Franklin Park, D. J. Harkins; (2) Middlesex Fells Zoo, Gregg. Neither was in the area of totality. Mr. Harkins watched the occupants of the large outdoor flying cage, and reports that all birds behaved as usual. One keeper watched the owls, but these showed no signs of activity. Mr. Gregg reports very little sign of unusual behavior among his birds, but three of nine great horned owls did become active, as if night was coming on.

Numerous reports of the behavior of canaries show the degree of individual reaction excellently. The majority went to roost, one acted as though very disturbed in addition, and another paid no perceptible attention to the eclipse at all.

DOMESTIC POULTRY.

The reports from the area of totality show overwhelmingly that nearly all kinds of domestic poultry acted in a subdued or quiet manner, the flock more or less huddled together, and in most cases went into their coops. The observers usually assumed that they went to roost, but one farmer took the precaution to check this and discovered that only one of his chickens had actually gone to roost with its head under its wing.

CHICKENS: As a whole these birds seemed more susceptible to the eclipse than wild native species. There are numerous reports of chickens going to roost in the area south of totality, or at least starting to do so. Roosters crowed very generally as darkness approached and receded. There are the usual individual variations. Some chickens did not go to roost; in other cases various individuals in one flock behaved differently. Two observers report that their chickens rushed for the coop at the moment of maximum darkness, after having acted in an uncertain and excited manner for some minutes.

PIGEONS: All reports show that pigeons went to roost. There is only one report of an individual pigeon remaining outside the dovecot, when its companions retired.

DUCKS: A flock of ducks at Colebrook, New Hampshire, were fed regularly at 5 P.M., returning from the lake for this purpose. They returned at 3 P.M. on August 31, departing in about fifteen minutes and returning at the proper time, two hours later.

GAME FARM SPECIES: A game farm at Wilton, New Hampshire, reports that chickens, pigeons, guinea fowl, geese, and ducks either started for their night quarters or went to roost. So did ring-necked pheasants, but golden and silver pheasants paid no attention to the eclipse at all.

I close this summary with the observations and comments of E. B. Hold at Denmark, Maine. Here a flock of turkeys started to return to the barn from the pastures at three P.M. when the sun was half obscured only, so that it was no darker than if there had been a light cloud. Mr. Hold makes the very interesting suggestion that as it was so light when the flock began making for the barn, they were possibly influenced more by the sudden drop in temperature than by the very slight failure of daylight.

WILD SPECIES.

There are comparatively few reports of the smaller native landbirds, for the obvious reason that the observers were primarily concerned with the eclipse, and selected good observation posts such as the tops of bare hills, which greatly limited the possibilities. On the coast, many careful studies were made of gulls, terns, and various shorebirds, which were in great abundance, and much more active and conspicuous than the majority of land-birds inland in late August.

Mr. and Mrs. Vernon Bailey, however, sent in an excellent summary from Squam Lake, New Hampshire. They observed or heard about ten species of birds in their immediate vicinity, and while none of them displayed any unusual behavior, it was noticeable that as the eclipse progressed, there was a decrease in the chorus of birds' notes and calls, and there was silence at the period of maximum darkness. Other observers confirm this general impression of the quieting down of diurnal birds. This was associated with numerous reports of the appearance of nocturnal birds. Owls hooted, whip-poor-wills called, and flocks of night-hawks appeared.

a. Nocturnal Birds.

1. SCREECH OWL—1 report of a bird calling at Framingham, Massachusetts.

2. BARRED OWL—Several reports of hooting from wilder sections in New Hampshire.

3. WHIP-POOR-WILL—1 report of a bird calling at Plymouth, New Hampshire.

4. NIGHT-HAWKS—Numerous reports of flocks appearing with approaching darkness from all over northern New England. These observations must, however, be partly discounted. The Night-hawk is at the peak of its southbound migration in late August, and it is not at all unusual to see them abroad in the afternoon. One observer is careful to report that the Night-hawks were about all the rest of the afternoon, though there were three hours of daylight after the eclipse was over.

b. Diurnal Land-birds Inland.

5. NORTHERN FLICKER—1 report of a bird which ceased feeding on the ground, and flew into a tree until the eclipse was over (Atlanta, Ontario).

6. BLUE JAY—A flock silent and quiet during period of maximum darkness (Quincy, Massachusetts).

7. CROW—5 reports on the behavior of crows. Four of these report flocks repairing to usual roosting place, sometimes silently, sometimes cawing. One report of a single bird flying wildly about during period of maximum darkness, as though excited and afraid (Atlanta, Ontario).

8. STARLING—Several reports of flocks repairing to usual roosting place. In one case a dozen birds left flock just before totality, and flew away in the darkness, an action perhaps attributable to some uncertainty of action (Nashua, New Hampshire, A. Loveridge).

9. ROBIN—One report, same as for Flicker above.

10. RED-WINGED BLACKBIRD—Small flock ceases feeding on ground and flies up into the trees until daylight returns (Atlanta, Ontario).

11. BRONZED GRACKLE—One report, exactly as for red-wing above. Another single bird at Nantucket, Massachusetts, ceased feeding on ground and looked up into sky as light returned.

12. HOUSE SPARROW—Numerous reports of flocks repairing to usual roosting places. In one case a single female remained behind on

feeding shelf, and continued to eat throughout the eclipse, as if nothing was happening.

13. GOLDFINCH—One report of a feeding flock which behaved precisely like the red-winged blackbird above.

c. Coastal and Marine Birds.

14. WILSON'S PETREL—Flocks following fishing trawler began to disappear as darkness increased. Presently other flocks appeared flying higher than usual and heading east. (George's Bank, Bay State Fishing Company).

15. BLACK-CROWNED NIGHT HERON—These birds roost in the salt meadow grass or in bushes during the day, and come out to the flats to feed at sunset. There are several reports of these birds appearing. On Plum Island, Massachusetts, however, where there are literally thousands, only a very few emerged in response to the darkness of the eclipse. "Two birds were discovered on a near-by mud flat as daylight returned. They stopped feeding, stood looking about, craning their necks, and often running rapidly a few steps. They gave every appearance of being uneasy and bewildered, and finally went back to roost again" (Griscom).

16. FISH HAWK—Several birds on Martha's Vineyard reported as milling around and whistling, as though excited, during period of maximum darkness (G. E. Spofford).

17. SEMIPALMATED PLOVER—Abundant at Newburyport and Plum Island, Massachusetts, both before and after eclipse (Aylward, Babson, Griscom). Showed no reactions to eclipse whatever except to stop feeding. A similar report from Martha's Vineyard (Spofford).

18. PIPING PLOVER—No reactions to eclipse (Martha's Vineyard, Spofford).

19. BLACK-BELLIED PLOVER—No reactions to eclipse at Plum Island, Massachusetts (Aylward, Babson, Griscom) or at Martha's Vineyard (Spofford).

20. DOWITCHER—Common on Plum Island meadows before eclipse. Flew off at approach of darkness and very few found in the region after the eclipse (Griscom).

21. LESSER YELLOW-LEGS—Abundant on the Plum Island meadows just before eclipse. At totality flew about calling loudly and the great majority left the region for good (Aylward, Babson, Griscom). On Martha's Vineyard, where the eclipse was not total, behavior entirely normal (Spofford).

22. WILLET—One bird under direct observation on Plum Island flew around restlessly, calling incessantly, but remained on the same mud flats (Griscom).

23. PECTORAL SANDPIPER—None under direct observation during eclipse, but common in the Plum Island meadows before the eclipse. Practically none to be found after the eclipse (Aylward, Babson, Griscom).

24. LEAST SANDPIPER—Common on Plum Island meadows before eclipse. For further comment see next species.

25. SEMIPALMATED SANDPIPER—Innumerable multitudes on Plum Island meadows before eclipse. As darkness approached, they rose up in great flocks to a much greater height than usual, and after whirling about in the darkness they disappeared. The entire area was almost devoid of these birds after the eclipse. The great Joppa Flats were fully exposed, as low tide prevailed during and after the eclipse, and they should have been covered with birds, but they were almost devoid of them (Aylward, Babson, Griscom). At Martha's Vineyard (no totality) these shore birds behaved normally (Spofford).

26. HERRING GULL—The reports of herring gulls are so numerous and the data so excellent that some discussion is well worthwhile. This species gives the best illustration available of the absolute necessity of being thoroughly acquainted with its habits in each special locality. On the coast of Maine and New Hampshire there are numerous rocky islets where the gulls breed, and it is their custom to return each evening from the mainland to roost. This is also true off the coast of Cape Ann, Massachusetts, but does not apply to Newburyport Bay or most of Cape Cod, where the bird spends the night either on the marshes or in some sheltered cove, estuary, or pond. In either case, it will be apparent that the exact roosting place must be definitely known before a flight of gulls during the eclipse could be presumed to be for this purpose, due to premature darkness.

In addition to these considerations, however, there are at least two other daily movements of the gulls north of Cape Cod, due to the relatively high tides. At high tide the gulls cease feeding and repair to various roosting places, which may or may not be the same as the night roosting places. On the approach of low tide there is a flight away from these places to feeding grounds exposed by the receding tides. It so happens that on August 31 the tide was *falling* during the eclipse, and some at least of the movement of gulls reported was due to their

desire for food being stronger than their alleged surprise at the arrival of premature darkness. In fact, the failure of the gulls to leave some jetty and repair to a recently exposed mud flat would constitute a definite eclipse reaction.

Another general habit of the herring gulls must also be given consideration. On pleasant days with a clear sky and a gentle breeze, gulls, when resting at high tide or not feeding, are much given to suddenly starting up in the air in flocks, and after some soaring aloft with more or less screaming they alight again. This action was frequently reported as an eclipse reaction. Now it may well have been an eclipse reaction, but it is equally certain that some gulls at least would have done this on a normal afternoon.

The reports show very definitely that there must have been some tendency on the part of the gulls to repair to their night roosting grounds, even when full allowance is made for the considerations mentioned above. On the other hand, from every station the reports show that only a part of the gulls present were affected, some apparently paying no further attention to the eclipse than to remain quiet, often looking constantly towards the sun.

Passing now to specific instances, the most interesting report received was from Mr. W. W. Ballard, who made special efforts to be landed on Duck Island, ten miles off Portsmouth, New Hampshire, where the gulls breed and congregate at night in great numbers. A confederate was stationed in Portsmouth Harbor to see if any gulls departed. The results at both stations were negative. No birds were seen to leave the Harbor, and no birds arrived at Duck Island, perhaps, as Mr. Ballard pertinently suggests, because the darkness did not last long enough for them to reach the Island, even if any had left the mainland. On the Island a small percentage of those present, all juveniles, tucked their heads under their wings. "At the moment of totality every gull on the Island, nearly, went screaming into the air . . . and flew aimlessly about as long as the sun was hidden."

Independent observation by three different people on Plum Island, Massachusetts, yielded slightly contradictory results. Two were stationed on the edge of the "Basin" where the gulls congregate at high tide, departing at low tide for the exposed flats in the harbor. When the eclipse was about 75% total, the gulls seemed to become mildly excited and finally all but six left for the harbor (Aylward and Babson).

The other observer (Griscom) was stationed near a breakwater,

on which about 100 gulls were roosting at high tide just before the eclipse commenced. Normally, they should have flown to the flats to feed, but they did not do so until the eclipse was practically over. A few birds did fly to the flats, but as darkness approached made no attempt to feed. As totality approached, the tide had fallen sufficiently to make it possible to walk out across the mud flats to the breakwater. One group of fifty remained huddled on the breakwater in perfect silence, and during the sixty-five seconds of totality permitted an approach within fifty feet, which so wary a bird would not have tolerated in the usual darkness of night. All three observers, however, agree that on the whole, the gulls showed distinctly less reaction than the terns and most of the shore birds.

At Kennebunk, Maine, Howard Cleaves noted some standing on nearby rocks, which remained where they were during totality, merely engaging in slightly increased vocal activity. A compact flock of fifty were, however, observed flying silently towards the outer reefs at a considerable height. It could not be determined whether they got there or whether they turned back with returning light. Mr. Spofford on Martha's Vineyard in Massachusetts reports a similar division of activity. About half the gulls under his observation remained where they were, while the others started for their roosting grounds on Muskeget Island, but were seen to return with returning light after they had gone about half a mile.

27. ROSEATE TERN—Small numbers observed at Plum Island with common terns. Actions exactly the same (Griscom).

28. COMMON TERN—At Kennebunk, Maine, about two hundred terns on the rock reefs did not fly away, but there seemed to be an increase of vocal activity during totality (Howard Cleaves).

On Plum Island, Massachusetts, the habits of the terns are the opposite of the gulls. They feed in the harbor chiefly at high tide, roosting on bars and mud flats at low tide. They were the first birds to react to the approaching darkness. While a few remained roosting on the ground, the great majority rose in the air in flocks, dashing about in an erratic manner, and some disappeared to the east (Aylward, Babson, Griscom). The terns on Martha's Vineyard acted in a similar manner (Spofford).

MAMMALS.

BY GLOVER M. ALLEN AND HAROLD J. COOLIDGE, JR.

Concerning the behavior of mammals in the path of the eclipse during the period of partial darkness, some one hundred and seventy observations were sent in, relating to twenty or more species, excluding those in "zoos." A brief summary of these follows, from which it will be seen that, except in the case of bats, for which all the evidence is necessarily of a positive nature, there is a good deal of conflicting testimony, as one might perhaps expect. In those species where the number of reports is great enough to be significant, it appears that some seemed affected rather definitely, though not uniformly, as cattle, sheep, and gray squirrels. With others the effect is less clear or negative. Mammals penned in zoological gardens reacted little, if at all, corroborating the usual impression which most species give—of having lost much of their interest in external conditions. In the case of dogs and cats, that are closely associated with man as his companions, it may be that they sensed his air of expectancy and responded to that rather than to the actual conditions of the eclipse. It is true, also, that individuals of both species are sometimes much frightened by thunder storms and may have felt apprehension at the darkening sky. One must expect, too, a range of differences in individual behavior within a given species. It should further be kept in mind that most observers have made few critical notes on the behavior of the species reported at times other than during the eclipse for comparison with behavior then.

BAT (*species?*)—Two were seen at North Sebago, Maine, and one at Hill, New Hampshire, flying about during the eclipse, both places being within the totality belt; also one each at Providence, Rhode Island, and Boston, Massachusetts, localities in the 98–100% area.

No specific identification is possible, but some at least were doubtless the Big Brown Bat (*Eptesicus fuscus*), an early flier and often a city dweller.

The appearance of bats is recorded in the case of previous solar eclipses, for in 1706 Todd records "bewildered bats" and in the total eclipse of May 1900, Mr. Tait in Oporto notes "a bat was seen flying about during totality." During the same eclipse bats appeared in another place.

In the present survey the result of bat observation is positive.

DOMESTIC DOG (*Canis familiaris*)—No less than twenty-two of the notes concern dogs and indicate differences of behavior in accord

perhaps with the individual temperament or surroundings. Of fifty dogs at the Animal Rescue League, Boston (98-100% area), it was thought that they seemed quieter than usual. In five other cases no unusual action was observed. At South Peabody, Massachusetts, dogs "turned in" as they do at night but got up and barked with excitement when the eclipse was over. At Attleboro Falls, Massachusetts, a dog showed great nervousness and crouched near its master. At Kennebunk, Maine, a dog seemed scared and stayed at its mistress's heels. At Brockton, Massachusetts, dogs yelped just after totality, and at Salisbury, New Hampshire, one barked during totality. A dog at Stony Brook, Connecticut, became uneasy and hid under a couch and at New Braintree one barked and showed excitement. Another at Washington, New Hampshire, a Chow pup, ran frightened under a shed and could not be coaxed out. At Conway, New Hampshire (totality area), one became scared and whimpered, while an Irish terrier at York Village, Maine, seemed much frightened and whimpered.

In general, then, it appears that while in about seven cases, dogs seemed to pay no attention to the darkening conditions, in about a dozen instances distinct excitement was noted, amounting in a half dozen or more to obvious fright. Doubtless in some instances, the intelligent animals sensed something unusual in the behavior of their masters, while probably others—as obviously in at least one case—reacted as if a thunderstorm were imminent and became frightened, whimpered, or tried to hide away.

Result: negative in about a third the cases reported; positive, perhaps either from excitement or fear, in slightly over half.

Records of previous eclipses are three at Lille Edet in Sweden in 1851.

"A half starved dog who was devouring some food dropped it from his mouth when the darkness came." In another place not far off two dogs showed no alarm and ate greedily of food given them just at totality. Finally two other dogs lay still during the eclipse but refused meat that was offered them.

RED FOX (*Vulpes fulva*)—Five observations concern both wild and captive individuals. Only one is of much value. At Randolph, New Hampshire, one barked during totality, a rather unusual day habit. A wild one was seen at Stony Brook, Connecticut, "sliding by," but foxes are often abroad at this time of day. At a Hinsdale, New Hampshire, fox farm an early emergence was noted.

Result: On the whole negative or doubtful.

MINK (*Mustela vison mink*)—One at Fitchburg, Massachusetts, in the 98-100% belt appeared; actions normal. They are often seen by day under usual conditions.

Result: Negative.

SKUNK (*Mephitis putida*)—A single observation is reported: On Cape Cod in the totality area, as it grew darker, skunks came out and started "rooting" in the lawn but hurried to their burrows with the return of full light, as if directly in response to darkness and light.

Result: Apparently positive.

RACCOON (*Procyon lotor*)—Two observations. A captive one at Suncook, New Hampshire (totality area), slept as at night though usually lively; others at East Westmoreland (98-100% area) behaved as they usually did.

Result: Negative or doubtful.

CAT (*Felis ocreata domestica*)—Thirteen notes on cats and kittens come about half (six) from the totality area, and the rest (seven) from the 98-100% area. In general no very obvious reaction appears that seems directly attributable to the eclipse. Some slept through it, or played as usual; in three instances cats seemed restless, one that had been resting under a lilac bush crawled out. Most of them showed no significant behavior. In one case, however, a Maltese at York Beach, Maine, is said to have "meowed" as twilight came on, gave a "shriek" as the corona appeared and rushed up a post, watching the sun all the time.

Result: Chiefly negative; one case of apparent fright.

In the records of the eclipse of 1851 in Sweden "a cat belonging to our neighbor ran to our maidservant and showed uneasiness by mewling."

HARBOR SEAL (*Phoca vitulina*)—A group of fifty on or near the rocks at Kennebunk, Maine, was unaffected.

Result: Negative.

COTTONTAIL RABBITS (*Sylvilagus*)—A few notes on cottontails relate their coming out to feed, as on Penikese Island (98-100% totality) and at Northfield, Connecticut (96-98% totality). However, since these animals are often abroad by day and especially in the latter part of the afternoon, these reports are of doubtful significance.

Result: Negative.

Tame "rabbits" (*Oryctolagus cuniculus*) in two reports were unaffected.

NORTHERN GRAY SQUIRREL (*Sciurus carolinensis leucotis*)—In three instances out of the eight reported, a possible effect was seen where squirrels (two cases) left the feeding boxes during totality and later returned or (one case) retired to their boxes and later emerged. In a fourth instance, one cutting off acorns at Squam Lake, New Hampshire, betook itself to the woods until the eclipse was over. Again, at Wells, Maine (totality area), two squirrels ceased "playing" and took to the woods without returning.

At Pachaug Pond, Connecticut (96-98% totality area) no unusual behavior was noticed.

Result: Probably a positive reaction, in line with the habit of this species of retiring promptly to its retreat at nightfall.

Scattering observations on red squirrels, flying squirrels, and chipmunks are negative or inconclusive.

WOODCHUCK (*Marmota monax*)—One reported from Watertown, Connecticut, is of no significance as they are often to be seen in the latter part of the day.

Result: Negative.

MUSKRAT (*Ondatra zibethica*)—Three were seen during the eclipse—two at Fitchburg, Massachusetts, and one at Stony Brook, Connecticut (96-98% totality area). Since they are abroad occasionally at any hour of the day, there is no special significance to the observations.

Result: Negative.

GUINEA-PIG (*Cavia porcella*)—One at Somerville, Massachusetts, is said to have gone into its house and stayed there as if frightened. The single instance is, however, inconclusive.

Result: Doubtful.

BEAVER (*Castor canadensis*)—Captive beaver were reported on in two instances, both in southern New Hampshire. Two at Nashua were very active during the eclipse, but their usual activities are not related. At Squam Lake an occupied house was watched and none came out.

Result: Inconclusive.

VIRGINIA DEER (*Odocoileus virginianus borealis*)—Six notes on deer were received. At Stony Brook, Connecticut, two does came out to drink at the edge of the river; single deer were sighted at Keene and Lisbon, New Hampshire. These three cases seem to have no unusual feature. Three others, however, seemed to indicate a little more. At Randolph, New Hampshire, a captive deer appeared restless and thrice got up and lay down again. At Bradford, New

Hampshire, four deer fed out in the open as at twilight, but as the light returned, seemed slightly bewildered and more alert. At the Poquannock Game Farm, Connecticut, the deer, as it grew dark, got to their feet, bunched under the apple trees, and started feeding. With the returning light, they wandered apart and presently lay down again.

Result: Probably positive, at least to some degree, when as in the last three cases, the growing darkness seemed correlated with activity and feeding.

WAPITI (*Cervus canadensis*)—One in semicaptivity at Bradford, New Hampshire, remained quietly in the clump of spruces where it was lying at rest.

Result: Negative.

RHESUS MONKEYS (*Macaca mulatta*)—Three reports of captive Rhesus monkeys agree in relating what seem positive reactions. At Nashua, New Hampshire, and at Bedford, Massachusetts (98-100% totality area), they huddled together as they usually do at evening, and at Hamilton Park, Connecticut, they climbed up into their house as at nightfall.

Result: An apparently positive reaction.

In the records of the total eclipse of May 1900 in Oporto a Dr. Barbra reports that he "saw monkeys go to boxes where they slept."

DOMESTIC GOAT (*Capra hircus*)—One observation only was quite negative—concerning a goat at Hingham, Massachusetts, that lay down in a field and continued to chew its cud contentedly.

Result: Negative.

In the eclipse of May 1900 at Oporto Mr. Slade reports that "a goat showed a total want of appreciation."

DOMESTIC SHEEP (*Ovis aries*)—Seven observations of sheep, all but one in New Hampshire and in the area of totality, showed notable differences of behavior. At Alstead, Lisbon, and Franklin, New Hampshire, as well as in the case of a large flock of five hundred and seventy at Center Sandwich, New Hampshire, they continued to feed undisturbed by the eclipse. In the three remaining cases there seemed to be a distinct response, similar to their evening behavior. At Lisbon Falls, Maine (totality area) a flock that was grazing peacefully became disturbed as darkness came on, and at exact totality the entire flock stampeded toward the barn; a flock at Conway, New Hampshire, also came in to their evening pens, bleating. In a third instance at Milan, New Hampshire, all the sheep huddled

in a bunch as they were accustomed to do for the night, but seemed in no way excited. Possibly the varying behavior may have been in part a result of differences in habit of the various groups, some being accustomed to return to shelter at evening, others used to remaining in pasture. Again the response of one or two individuals in a group may have affected the actions of all as in "stampeding" for the barn.

Result: Positive in less than half the cases, inducing flocks to react as at evening; negative in the other cases.

In the eclipse of July 1851 in Sweden a flock of sheep was reported bleating during the whole period.

DOMESTIC CATTLE (*Bos taurus*)—Some seventy-two observations on the effect of the eclipse on the activities of cattle were received, of which 39 are from within the area of totality. Of these 39, only ten are negative. It is interesting, however, that even in the center of the totality area, differences in reaction were seen. Thus at Conway and North Conway, New Hampshire, in three cases, cows seemed quite unconcerned. In 29 of the 39 cases, however, there was a quite definite response to the oncoming of darkness, in most instances a starting in the direction of the barn, a feeding toward the barn, or arriving at the bars of the pasture or barnyard ahead of the usual milking time. In the area of 98 to 100% totality the reaction was somewhat similar, but in the area of 96 to 98% the reaction was in most cases negative.

Result: Positive in about two-thirds of the cases. Thus, by way of summary, of 72 observations, no less than 43 may be classed as positive, 21 negative, 8 doubtful. The preponderance of evidence seems to indicate that coming home to be milked and housed for the night is in part at least a reaction to lessening daylight.

In the eclipse of 1851 in Sweden during totality a herd of oxen collected themselves into a circle and stood with horns facing outward. Also cows which were lying down in a meadow at the beginning of the eclipse continued there while totality lasted, when they got up and went to the gate to go home.

HORSE (*Equus caballus*)—Of the eight observations sent in on horses in pastures, one is without the 96% area and is quite negative. In the areas of 96% to near totality, three other observations are equally negative, no reaction being noticed. Four notes are from within the area of totality, namely, Tilton, New Hampshire—kept on feeding in the pasture; Canaan, New Hampshire—no change

observed; Squam Lake, New Hampshire,—horses grazed up to the corner near the barn; Exeter, New Hampshire—horses gathered, neighing, at the pasture gate.

Result: In only one case, the last, did there seem to be any response similar to that of the evening return to the barn. In the remaining seven, the results seemed quite negative. No clue to any supposed difference is hinted at, although, again, individual peculiarities of habit may account for the actions observed.

In the 1851 eclipse in Sweden two references to horses showed them to be unaffected.

ANIMALS IN CAPTIVITY.

Reports in considerable detail were sent in from the following zoos or collections of animals:

Benson's Animal Farm at Nashua, New Hampshire; Franklin Park Zoo, Boston, Massachusetts; Middlesex Fells Zoo, Boston, Massachusetts; Bedford Zoo, Bedford, Massachusetts; and Hamilton Park Zoo, Connecticut.

In each case there was no behavior that could be interpreted as a direct result of the eclipse, except that of the Rhesus monkeys already referred to. The following animals were those on whose behavior reports were received by the Committee:

Elephants, lions, leopards, tigers, pumas, jaguars, lynx, wolves, coyotes, foxes, hyenas, African and Indian antelopes, bison, yak, musk-oxen, deer (many species), wapiti, zebras, camels, llama, bears, Rhesus monkeys, baboons, mandrills, and chimpanzees.

SUMMARY.

By way of summary, the observations on ten of the twenty-one species seem quite negative or at least inconclusive, namely in the case of red fox, mink, raccoon, harbor seal, cottontail rabbit, woodchuck, muskrat, beaver, wapiti, goat. The evidence in the case of cats and horses is likewise practically negative, with one or two individual instances in which fright or restlessness seemed to be betrayed. Excluding the single instance of a guinea-pig that retreated to its shelter, as being inconclusive, there then remain eight species that seem to have been definitely affected, though in varying degree, by the early darkening of the sun's light. These are: dog, bat, skunk, gray squirrel, Rhesus monkey, Virginia deer, domestic sheep, and cows. It is interesting to find that in the dog, reactions were noted in about one-half the instances, and were ex-

pressed either as excitement or fright. As before suggested, the atmosphere of excitement may have been imparted by their human companions or possibly there was actual apprehension of an approaching storm indicated in a few cases. All the remaining seven species behaved as they would normally have done at the approach of night. The bats left their diurnal shelter to feed, as did also the skunks and deer. The gray squirrels and Rhesus monkeys, which are strictly day-living mammals, seemed on the other hand, to prepare for the night's rest, and retired for the time in a rather definite way. The sheep were less uniformly affected, for in only about half the cases did they seem to huddle together in the pasture or approach their barns as if for the night. Cows showed a definite reaction in about two-thirds of the cases reported, by coming to the pasture bars or their barnyards well ahead of their usual hour for milking. In the case, then, of the seven mammals last mentioned, the behavior seemed to be significant of a definite reaction to the gradual lessening of daylight simulating the oncoming of night.

Among the mammal observations, with the possible exception of excitement and fright among the dogs, none of the behavior which was recorded was in any way abnormal in the response to the sudden darkening caused by the eclipse. Many people have reported a personal feeling of sickness or fright during totality and shown it in their behavior. In the total eclipse of 1560 and 1567 "women screamed and fainted." In 1900 "a country woman was seen on her knees praying aloud and seizing handfuls of earth which she put in her mouth."

The survey of mammal behavior has shown no demonstration of extreme nervous or mental disturbance such as that recorded of *Homo sapiens*.

APPENDIX.

FLOWERS.

Unfortunately, very few observations were sent in to the Eclipse Committee describing the effect that the darkness or sudden change of temperature had on plants. There is no reason why many crepuscular species should not have shown the effect. The only reports to quote are those of M. J. Cook of Melrose, Massachusetts, which were as follows:

"The morning glories began to close at three-fifteen."

"The portulacas began to close at three-twenty-five."

At Warner Village, New Hampshire, some devil's paint-brush closed as for the night.

In the records of previous eclipses we find the following brief references:

Total eclipse of the sun—1706: Some flowers closed.

Eclipse of 1851—July 28: Some flowers closed.

L. Svangren—Lille Edet: Night violet which shortly before the beginning of the eclipse had little of its agreeable scent, smelt strongly during the totality.

